Transportation Consultants
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MEMORANDUM

To: Jeff Hammond, P.E., Metro Nashville Public Works

From: Jonathan Cleghon, P.E., RPM Transportation Consultants, a Division of KCI Technologies

Date: June 2, 2017

Project: Hillsboro Village Pedestrian Crossing Evaluation

RE: Crosswalk on 21st Avenue South at Belcourt Avenue

Introduction

Hillsboro Village has been one of Nashville's most vibrant activity centers for many years. Recent redevelopments at the southern end of Hillsboro Village continue to make the area a hub for activity. A challenge of Hillsboro Village is its urban location with pedestrian oriented storefronts and the fact that 21st Avenue South, which bisects Hillsboro Village, is a major arterial route with state (TN 106) and federal (US 431) designations. 21st Avenue South not only serves Hillsboro Village, but traffic having origins and destinations like downtown, Vanderbilt, numerous hospitals, I-440, Green Hills, and the surrounding residential neighborhoods. The varied demand on right-of-way use between pedestrians and vehicles creates the need for an additional safe pedestrian crossing between the signalized intersections of Wedgewood Avenue and Acklen Avenue, which are separated by approximately 700 feet. As Hillsboro Village continues growth and redevelopment the increase in pedestrian activity will further emphasize the need for a safe pedestrian crossing. This memorandum provides the results of analyses conducted to study the need for a new pedestrian crossing on 21st Avenue South in Hillsboro Village. The following includes a brief description of the study area and analysis as well as recommendations to improve interaction and operation between vehicles and pedestrians in Hillsboro Village.

Existing Conditions

Hillsboro Village is an area generally bound by Capers Avenue to the north, Fairfax Avenue to the south, 19th Avenue South to the east, and what would be the extension of 23rd Avenue South to the west. Hillsboro village began forming as a commercial center in the 1920s serving the surrounding residential neighborhood and benefited from being located on a streetcar line. Today, Hillsboro Village and 21st Avenue South continue to provide a diverse mix of businesses in a pedestrian oriented environment while also serving as a vital component of midtown's transportation network.

21st Avenue South runs in a north-south direction providing connectivity between I-440 and Green Hills to the south and downtown to the north through Vanderbilt University's campus. 21st Avenue

South includes two travel lanes in each direction with a shared center turn lane through Hillsboro Village. The posted speed limit on 21st Avenue South is 30 mph. Sidewalks exist along both sides of 21st Avenue South. On-street parking is permitted in the curb-side lanes of both northbound and southbound 21st Avenue South during off-peak traffic times. This effectively reduces 21st Avenue South to one travel lane in each direction during the majority of the day. Parking is prohibited on 21st Avenue South from 7AM-9AM and 4PM-6PM, Monday through Friday.

Belcourt Avenue is a two lane roadway with one travel lane in each direction running in an east-west direction and meeting 21st Avenue South at an offset intersection in the heart of Hillsboro Village. The eastern leg of Belcourt Avenue (northern intersection) is offset approximately 80 feet to the north of the western leg. The western leg of Belcourt Avenue with 21st Avenue South (southern intersection) is located approximately mid-way between the signalized intersections at Wedgewood Avenue and Acklen Avenue. Both legs of Belcourt Avenue are controlled with stop signs at their intersection with 21st Avenue South. Sidewalks and on-street parking exist along both sides of Belcourt Avenue. The speed limit on Belcourt Avenue is 30 mph. A variety of restaurants and shops are served by Belcourt Avenue both east and west of 21st Avenue South. Redevelopment of several buildings, including renovation of the Belcourt Theater, has recently occurred and has likely added to an increase in pedestrian activity.

Given its central location in Hillsboro Village, Belcourt Avenue has long been considered as an appropriate location for improved pedestrian crossing. Field observations of the area along with pedestrian counts and the presence of an MTA bus stop indicate a large number of pedestrians cross 21st Avenue South in the vicinity of Belcourt Avenue. In addition, a Hillsboro Village traffic study completed by RPM Transportation Consultants in December of 2010 recommended a new crosswalk with push-button activated warning beacons at Belcourt Avenue. Based on this information and for the purpose of this study, the location of a new crosswalk in Hillsboro Village was focused at the intersections of Belcourt Avenue with 21st Avenue South. The study area is presented in Figure 1.

Figure 1: Study Area

Data Collection

RPM collected video counts for vehicles, pedestrians, and bicyclists traveling 21st Avenue South and Belcourt Avenue on May 11-13, 2017. During this time period Vanderbilt University classes were no longer in session, however, commencement ceremonies were held May 12. Metro Nashville public schools were in session during this time. Figure 2 represents existing weekday peak hour vehicle volumes and Figure 3 represents corresponding weekday pedestrian volumes during the same time period at the intersections. Weekday peak hours occurred from 7:15AM to 8:15AM and 4:30PM to 5:30PM. Figure 4 represents existing Saturday midday peak hour vehicle volumes and Figure 5 represents corresponding Saturday pedestrian volumes during the same time period at the intersections. The Saturday midday peak hour occurred from 12:00PM to 1:00PM. In addition to video counts, RPM conducted multiple site visits to review roadway and intersection characteristics. Site visits evaluated intersection operation, on-street parking, sight distance, transit stop locations, driveway locations, and curb ramps.

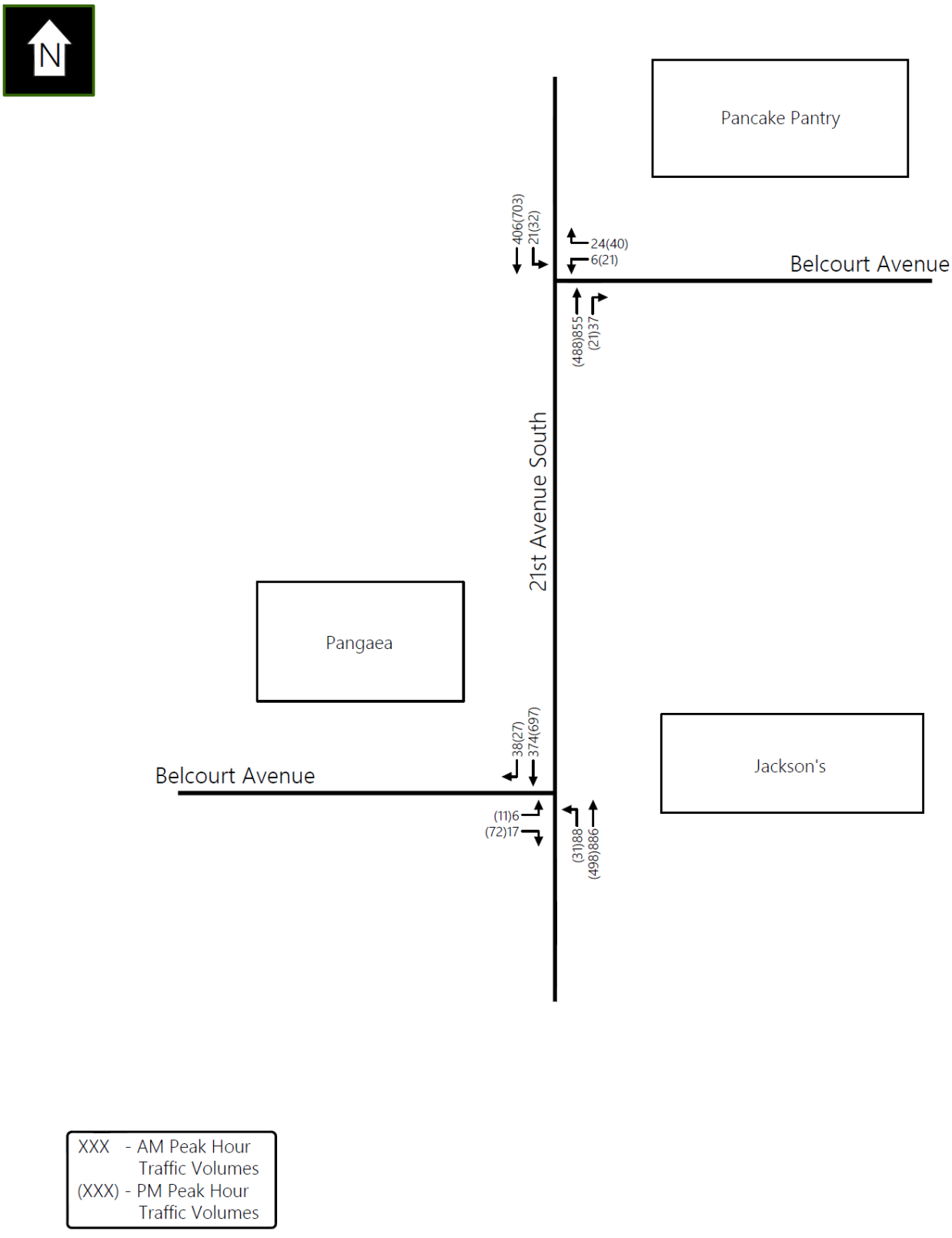


Figure 2: Existing Weekday Peak Hour Vehicle Volumes

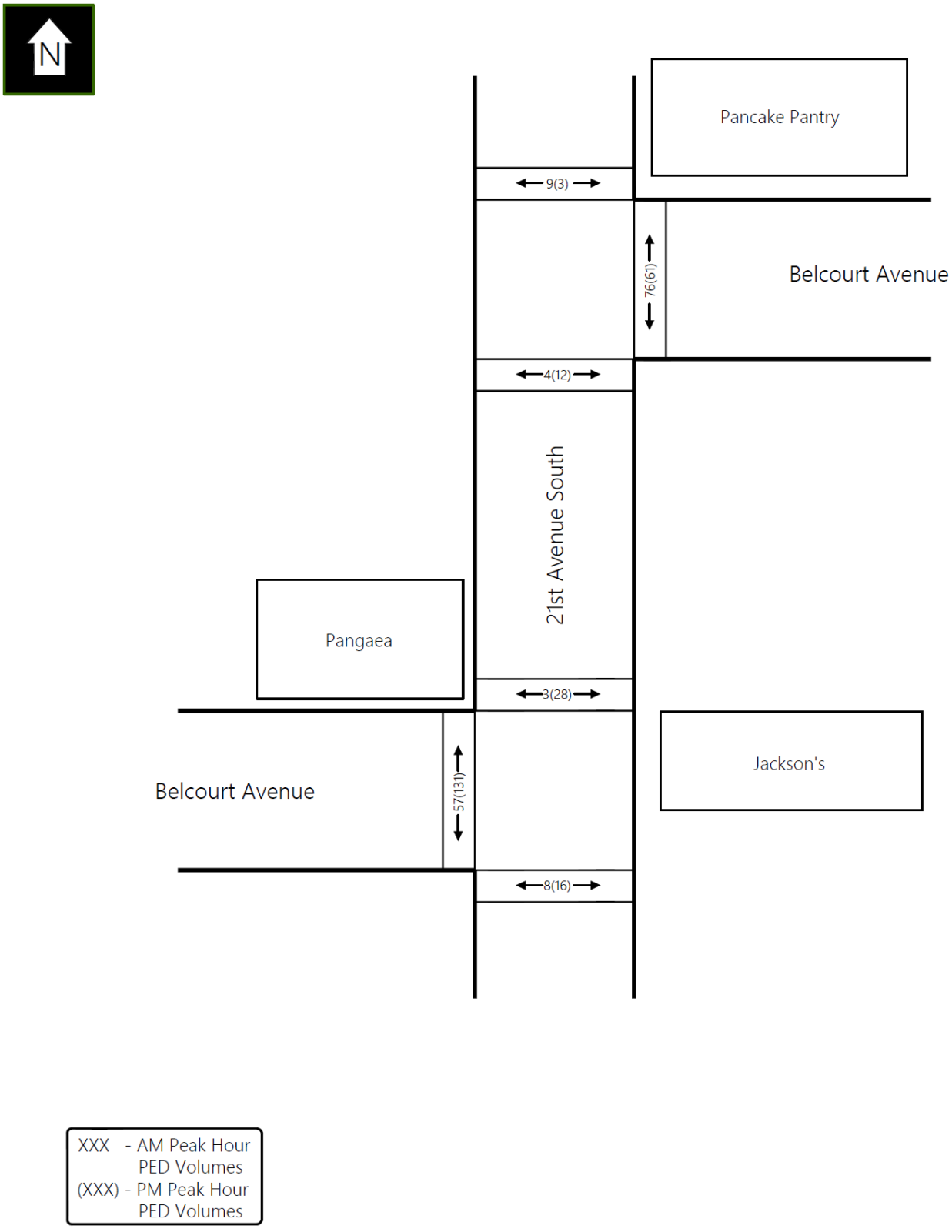


Figure 3: Existing Weekday Peak Hour Pedestrian Volumes

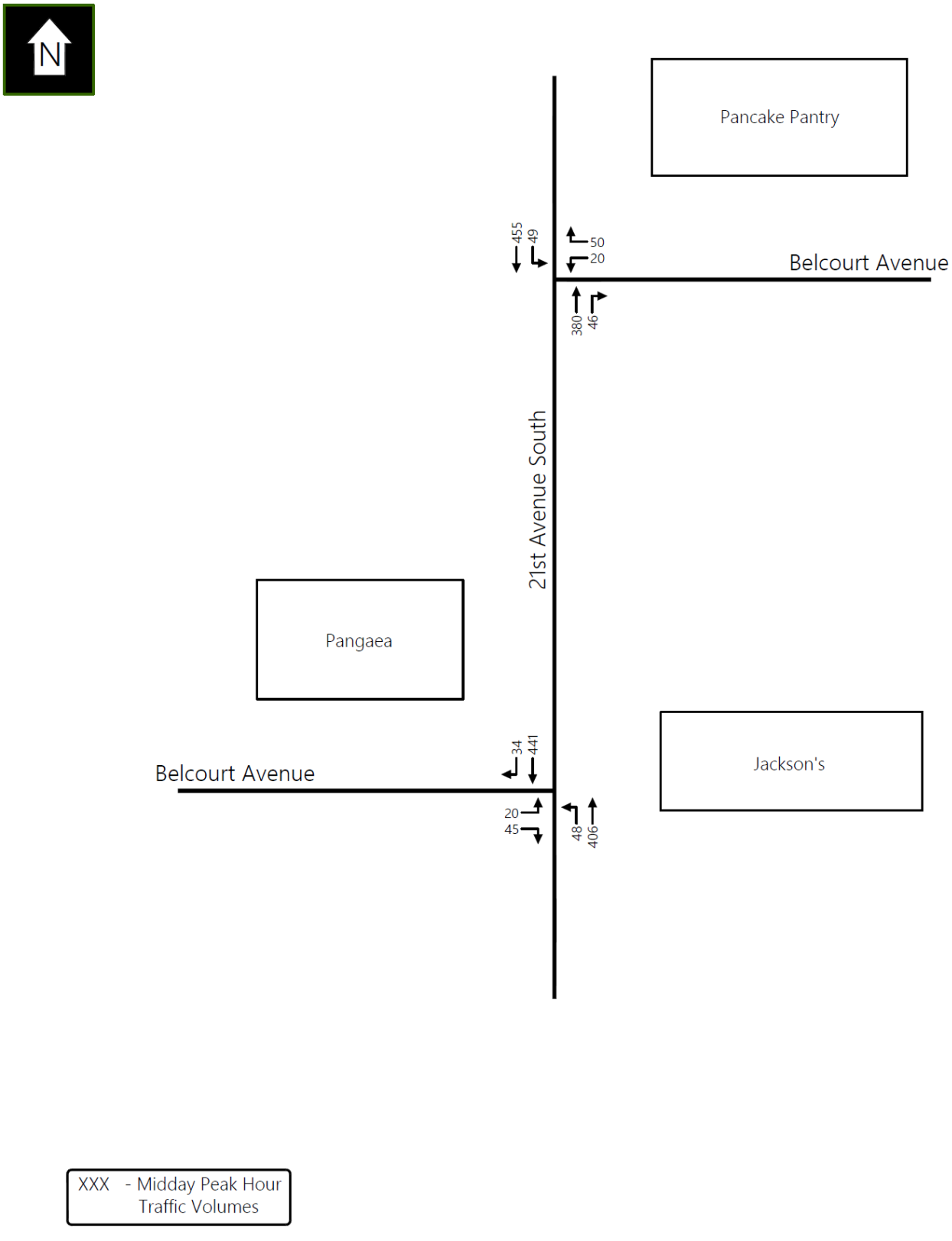


Figure 4: Existing Saturday Midday Peak Hour Vehicle Volumes

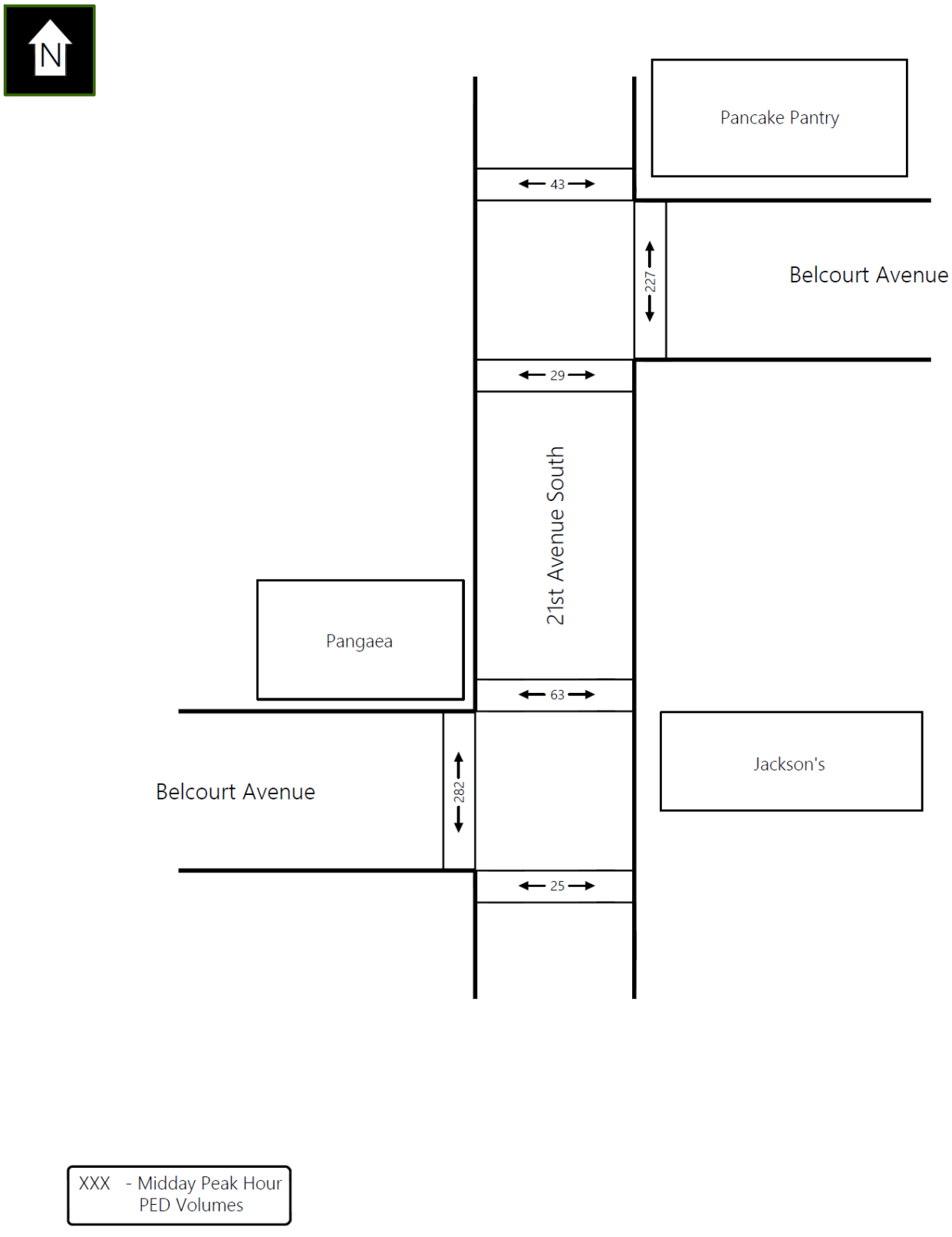


Figure 5: Existing Saturday Midday Peak Hour Pedestrian Volumes

During site visits, the majority of pedestrians crossing 21st Avenue South were observed at the southern intersection of Belcourt Avenue with more pedestrians crossing on the north side of the intersection than the south side. Count data confirmed this condition as shown in Figures 3 and 5.

Sight distance at the stop signs on Belcourt Avenue is limited by the presence of on-street parking. Vehicles routinely park on both sides of 21st Avenue South up to the corners of the intersections. "No Parking to Corner" signs are not posted at the intersection. However, this condition is prohibited by Metro Code Chapter 12.40.040, which prohibits parking within 30 feet of an intersection. Sight distance could be improved if vehicles were prevented from parking within sight lines at the intersections.

MTA has signs posted marking bus stops both northbound and southbound on 21st Avenue South as shown in Figure 1. The northbound stop is signed just south of the east leg of Belcourt Avenue. The southbound stop is signed just north of the west leg. This places both stops within the offset of the Belcourt Avenue intersections. MTA routes 7 and 91X both pass through Hillsboro Village on 21st Avenue South. Currently, there are no shelters or benches provided at either stop. MTA's nMotion transit strategic plan recommends arterial running BRT on 21st Avenue South between Downtown and Green Hills. If implemented, pedestrian activity would likely increase in Hillsboro Village.

Jackson's Bar and Bistro has an existing driveway serving a parking lot on the east side of 21st Ave S within the offset Belcourt Avenue intersections. The driveway is located in an area that would still allow construction of an ADA compliant curb ramp for a crosswalk at either intersection. Google Fiber has a pull box in place where a curb ramp would be installed on the north side of the southern intersection. This pull box would need to be relocated by Google to install a crossing at the location. A large, mature tree exists on the east side of 21st Avenue South in direct conflict with installation of a pedestrian crossing on the south side of the southern intersection. The tree would need to be completely removed in order to install a crosswalk at the location.

Existing Conditions Analysis

The Manual on Uniform Traffic Control Devices (MUTCD) sets forth nine different warrants that have been developed by the traffic engineering profession to facilitate the determination of whether a traffic signal is warranted. These warrants include minimum conditions that normally indicate when a traffic signal is justified at a particular location. The MUTCD states "traffic control signals should not be installed unless one or more of the signal warrants in the manual are met." Although the MUTCD provides nine different warrants, only five of these are potentially applicable to the intersections under study. The following five traffic signal warrants were evaluated in order to determine if a traffic signal is justified at the intersection of 21st Avenue South and Belcourt Avenue.

- Warrant 1: Eight-Hour Vehicular Volume
    - A) Minimum Vehicular Volume
    - B) Interruption of Continuous Traffic
    - C) Combination
- Warrant 2: Four-Hour Vehicular Volume
- Warrant 3: Peak Hour
- Warrant 4: Pedestrian Volume

- Warrant 7: Crash Experience

The vehicle and pedestrian volumes from May 11-13, 2017, and crash data from April 2013 through March 2016 were used to evaluate traffic signal warrants. The results of the traffic volume-related signal warrant analysis are shown in Table 1 and pedestrian volume-related analysis are shown in Table 2.

Table 1. Traffic Volume-Related Signal Warrant Analysis

Hour	Traffic Volumes		Warrants Met?				
	21st Ave South Both Directions	Belcourt Ave Highest Approach	#1A	#1B	#1C	#2	#3
7:00-8:00 AM	1,381	6	--	--	--	--	--
8:00-9:00 AM	1,170	14	--	--	--	--	--
11:00 AM-12:00 PM	941	20	--	--	--	--	--
12:00-1:00 PM	939	20	--	--	--	--	--
4:00-5:00 PM	1,189	21	--	--	--	--	--
5:00-6:00 PM	1,258	15	--	--	--	--	--
		TOTAL	0	0	0	0	0

Notes: 1) Warrants 1A, 1B, and 1C must be satisfied for at least 8 hours of a typical day. Warrant 2 must be met for at least 4 hours, and Warrant 3 must be met for at least one hour of a typical day. 2) Volume warrant requirements are based on two-lane major approaches, one-lane minor approaches, and a posted speed limit of 30 mph on the major road. 3) Right-turn volumes were not included on the Belcourt Ave approaches.

Table 2. Pedestrian Volume-Related Signal Warrant Analysis

Hour	Traffic Volumes	Pedestrians	Warrant Met?
	21st Ave South Both Directions	Belcourt Ave All Pedestrian Crossings	#4
7:00-8:00 AM	1,381	16	--
8:00-9:00 AM	1,170	28	--
11:00 AM-12:00 PM	941	95	--
12:00-1:00 PM	939	88	--
4:00-5:00 PM	1,189	42	--
5:00-6:00 PM	1,258	40	--
		TOTAL	0

Crash data at the intersection of 21st Avenue South and Belcourt Avenue for the period from April 2013 through March 2016 was assembled and reviewed in order to determine if the intersection meets the criteria set forth in Warrant 7 (Crash Experience). The conditions of this warrant are intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal. To satisfy this warrant, five or more reported crashes susceptible to correction by a traffic control signal must have occurred at the intersection within a 12-month period. In addition, to meet

the requirements of Warrant 7, the traffic volumes at the intersection must satisfy 80% of the minimum volumes required by Warrant 1A or Warrant 1B for a minimum of 8 hours of an average day.

The crash history for this intersection shows that seven crashes occurred over a span of three (3) years between 4/1/2013 and 3/31/2016 that would be susceptible to correction by a traffic control signal as shown in Table 4. Of note, two crashes involving a pedestrian occurred in 2013. One of the crashes occurred in the vicinity of the Belcourt Avenue intersection and may have been prevented if the pedestrian had the opportunity to cross 21st Avenue South at a marked crosswalk. The second crash (not shown in Table 4) was determined to have occurred in a private parking lot and would not have been prevented by a marked crosswalk at Belcourt Avenue.

Table 4. Summary of Crashes Susceptible to Correction by a Traffic Control Signal

Crash Type	Crash Date	Day of Week	Adverse Condition	Light Condition	Manner of Collision
Property Damage	5/2/2013	Thursday	None	Dark - Lighted	Angle
Injury	9/7/2013	Saturday	None	Daylight	Angle
Injury	10/10/2013	Thursday	None	Dark - Lighted	Pedestrian
Property Damage	11/6/2013	Wednesday	Rain	Dark – No Light	Angle
Property Damage	6/20/2014	Friday	None	Daylight	Angle
Property Damage	6/29/2015	Monday	None	Daylight	Angle
Property Damage	3/7/2016	Thursday	None	Daylight	Head-on

As shown in the tables, none of the five signal warrants evaluated for this location were met. Additional information on signal warrants can be found in Appendix B. Therefore, alternative measures for controlling vehicle and pedestrian traffic should be considered to provide an improved pedestrian crossing at the intersection of 21st Avenue South and Belcourt Avenue. The pedestrian crossing treatments considered in lieu of a traffic signal can be summarized as follows:

- Pedestrian activated Rectangular Rapid Flashing Beacons (RRFB) with high visibility warning signs and pavement markings
- High visibility static warning signs and pavement markings
- Pedestrian activated overhead flashing warning beacons with high visibility warning signs and pavement markings
- Pedestrian activated hybrid beacon (HAWK signal) with high visibility warning signs and pavement markings

A brief description of each pedestrian crossing treatment can be found below. Conceptual designs representing the pedestrian crossings treatments can be found in Appendix A. All options considered include making the crossing fully compliant with recommended ADA guidelines including installation of curb ramps and detectable warnings.

Rectangular Rapid Flashing Beacons (RRFB)

In combination with the high visibility warning signs and pavement markings detailed above, push button activated Rectangular Rapid Flashing Beacons (RRFB) can be installed to enhance pedestrian visibility. Buttons are provided at both ends of the crosswalk that, when pushed by a pedestrian, activate the RRFBs. RRFBs are amber LED lights that flash in an irregular pattern similar to emergency flashers on police vehicles. Since RRFBs are only activate when a pedestrian pushes the button and stutter flash in a way that elicits motorist attention they have proven to be very effective at encouraging drivers to yield. RRFBs are a lower cost alternative to traditional traffic signals and overhead warning flashers since they are mounted on the roadside rather than overhead. However, being mounted on the roadside also means they could be less visible to motorists. Particularly on an urban, multi-lane roadway with on-street parking like 21st Avenue South in Hillsboro Village. Conceptual designs representing RRFBs are represented as Options 1 and 4 in Appendix A. The cost for installation is estimated at $80,000.

High visibility static warning signs and pavement markings

Standard treatment of pedestrian crossings at non-signalized intersections typically includes installation of pedestrian warning signs (W11-2) and crosswalk pavement markings. These measures can be supplemented with additional signs reminding motorists that state law requires yielding to a pedestrian (W16-7p), signs indicating the appropriate position where yielding should occur (R1-5A), and yield line pavement markings. The pros associated with this type of installation are low cost and consistent motorist understanding. These crosswalk treatments are commonly encountered in urban areas and are understood by motorists. However, since there is no provision for a pedestrian to indicate their presence other than physically entering the crosswalk, these treatments may be overlooked by motorists. Static signs, while effective in certain situations, may not be as effective in urban environments with on-street parking as more dynamic treatments at alerting motorists to the presence of a pedestrian in the crosswalk. Conceptual design representing high visibility static warning signs and pavement markings is represented as Option 2 in Appendix A. The cost for installation of Option 2 is estimated at $40,000.

Overhead Flashing Warning Beacons

Overhead Flashing Warning Beacons are pedestrian actuated with push buttons similar to RRFBs and are intended to supplement the high visibility warning signs and pavement markings detailed above. Instead of being mounted on the roadside they are positioned overhead on traditional traffic signal mast arm supports. The beacons flash in a regular pattern either amber or red, depending on the direction of traffic. In addition to the beacons, overhead mounted pedestrian crossing signs (R1-9) can be installed to further emphasize the crossing location. Overhead Flashing Warning Beacons are clearly visible to drivers and since they are only activated in the presence of a pedestrian they are effective at alerting motorists to the crosswalk. Overhead positioning of the beacons would make them more visible on an urban, multi-lane roadway with on-street parking like 21st Avenue South in Hillsboro Village. Of the three pedestrian crossing treatments detailed thus far, Overhead Flashing Warning Beacons would be the costliest. Conceptual designs representing Overhead Flashing Warning Beacons are represented as Options 3 and 5 in Appendix A. The cost for installation is estimated at $125,000.

Pedestrian activated hybrid beacon (HAWK signal)

As detailed in Chapter 4F of the MUTCD, pedestrian hybrid beacons are a special type of traffic signal used to warn and control traffic at marked, mid-block pedestrian crossings. The preferred location of a crossing

in Hillsboro Village is at one of the Belcourt Avenue intersections. Since the MUTCD only permits HAWK signal installation at mid-block pedestrian crossings, the HAWK signal was determined to be an unsuitable measure for this location.

Community Meeting

A community meeting was held on Thursday, May 18, 2017, to discuss possible solutions for providing a pedestrian crossing on 21st Avenue South in Hillsboro Village. In attendance were Council Member Berkley Allen, Metro Public Works, RPM Transportation Consultants, and several members of the community representing area businesses and organizations. The pedestrian crossing treatments detailed above and shown in Appendix A were presented at the meeting by RPM and Metro Public Works. The HAWK signal was not presented since it was determined to be unsuitable for this location. General consensus of the group was achieved on two items.

- First was that the crosswalk would be best located at the southern intersection of Belcourt Avenue. Most pedestrians cross at the southern intersection today and attempting to change that pattern could prove ineffective. Additionally, the southern intersection is more centrally located in Hillsboro Village.
- Second was the preference for Overhead Flashing Warning Beacons. The desire for pedestrian actuated warning flashers was clear since static signs could become unnoticed. Overhead Flashing Warning Beacons were preferred over RRFBs due to their increased visibility over the roadway and the concern that random flashing LEDs could negatively impact outdoor dining areas.

Consensus was not as clear on which side, north or south, of the southern intersection the crosswalk should be installed. Attendees expressed concern over loss of on-street parking. Installing a crosswalk on the north side of the southern intersection requires the removal of 3 parking spaces total, 2 of which are not permitted by Metro Code. Installing a crosswalk on the south side of the southern intersection requires the removal of 4 parking spaces total, 1 of which is not permitted by Metro Code. Some attendees expressed concern over potential removal of the large, mature tree while other attendees considered removal of the tree to be beneficial. Additionally, safety concerns were expressed with regard to installing the crosswalk on the south side of the intersection. Right-turning eastbound motorists exiting Belcourt Avenue would typically be looking left at southbound traffic on 21st Avenue South while turning right toward the crosswalk. Adding to this concern is the fact that right turns account for the majority of traffic on eastbound Belcourt Avenue. It would be preferable from a safety perspective to have the crosswalk on the left while eastbound motorists look left at southbound traffic.

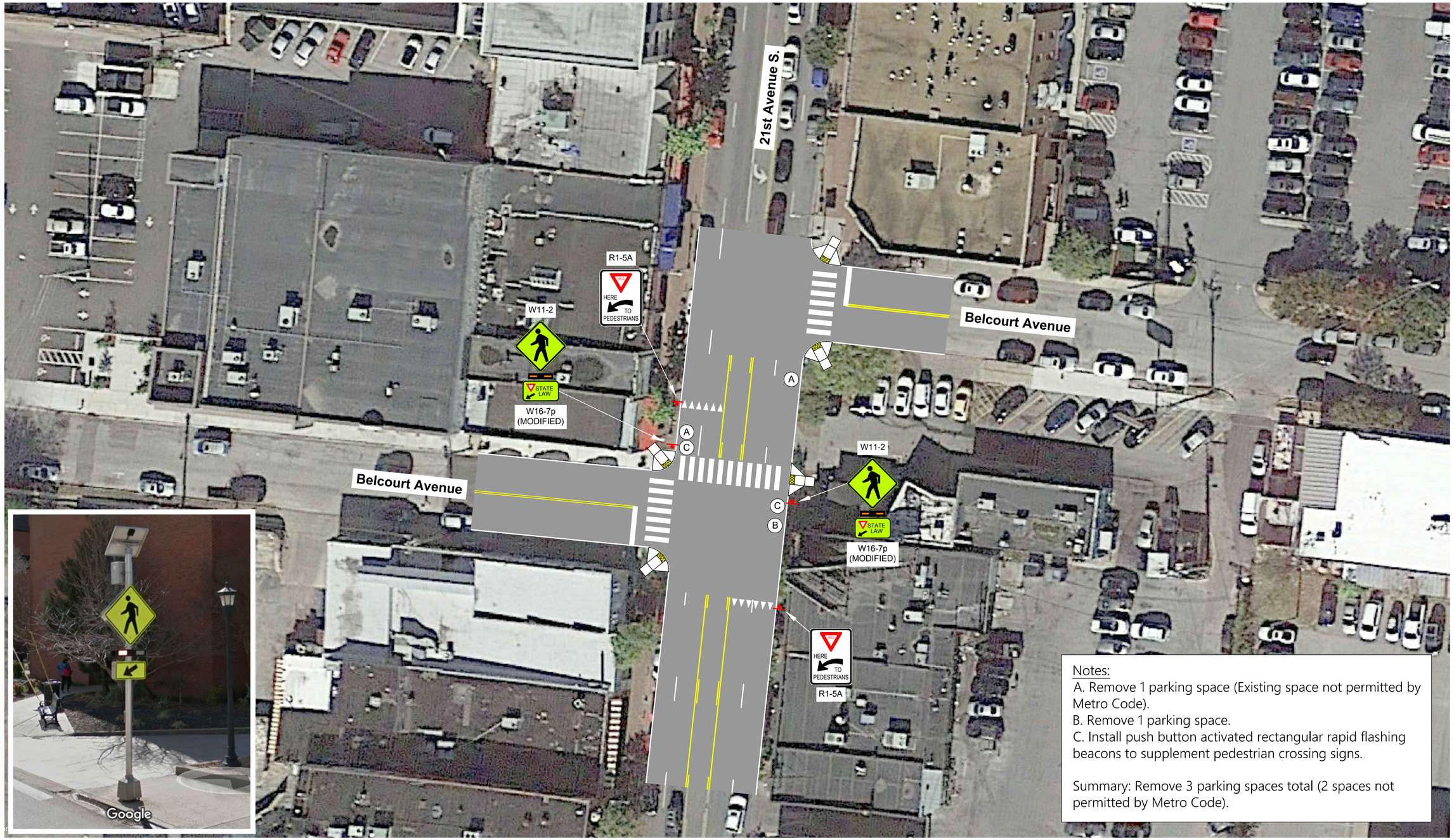
Conclusions and Recommendations

Based on the existing conditions analysis, field observations, and community meeting detailed above, the following are recommended to provide an improved pedestrian crossing on 21st Avenue South on the north side of the southern intersection of Belcourt Avenue in Hillsboro Village. The scenario is represented as conceptual design Option 3 in Appendix A.

- Install push button activated Overhead Flashing Warning Beacons in combination with high visibility signs and pavement markings on the north side of the southern intersection at Belcourt Avenue and 21st Avenue South.
- Install ADA compliant curb ramps on both sides of the new crosswalk as well as all other corners at the intersections of 21st Avenue South and Belcourt Avenue.
- Install "No Parking" signs at three spaces to improve visibility of the crosswalk and for motorists exiting Belcourt Avenue. One space facing northbound within the intersection south of the proposed crosswalk. One space facing northbound between Belcourt Avenue and Jackson's driveway (prohibited by Metro Code). One space facing southbound north of the proposed crosswalk (prohibited by Metro Code).
- Trim trees as needed on the east and west sides of 21st Avenue South that extend over the roadway in order to make the flasher more visible to motorists.
- In addition to crosswalk markings across 21st Avenue South it is recommended that crosswalks be marked parallel to 21st Avenue South at both Belcourt Avenue intersections. Since both intersections are controlled with stop signs, no additional warning measures are required.

APPENDIX A

Pedestrian Improvements
21st Avenue South at Belcourt Avenue in Hillsboro Village



Notes:
A. Remove 1 parking space (Existing space not permitted by Metro Code).
B. Remove 1 parking space.
C. Install push button activated rectangular rapid flashing beacons to supplement pedestrian crossing signs.

Summary: Remove 3 parking spaces total (2 spaces not permitted by Metro Code).

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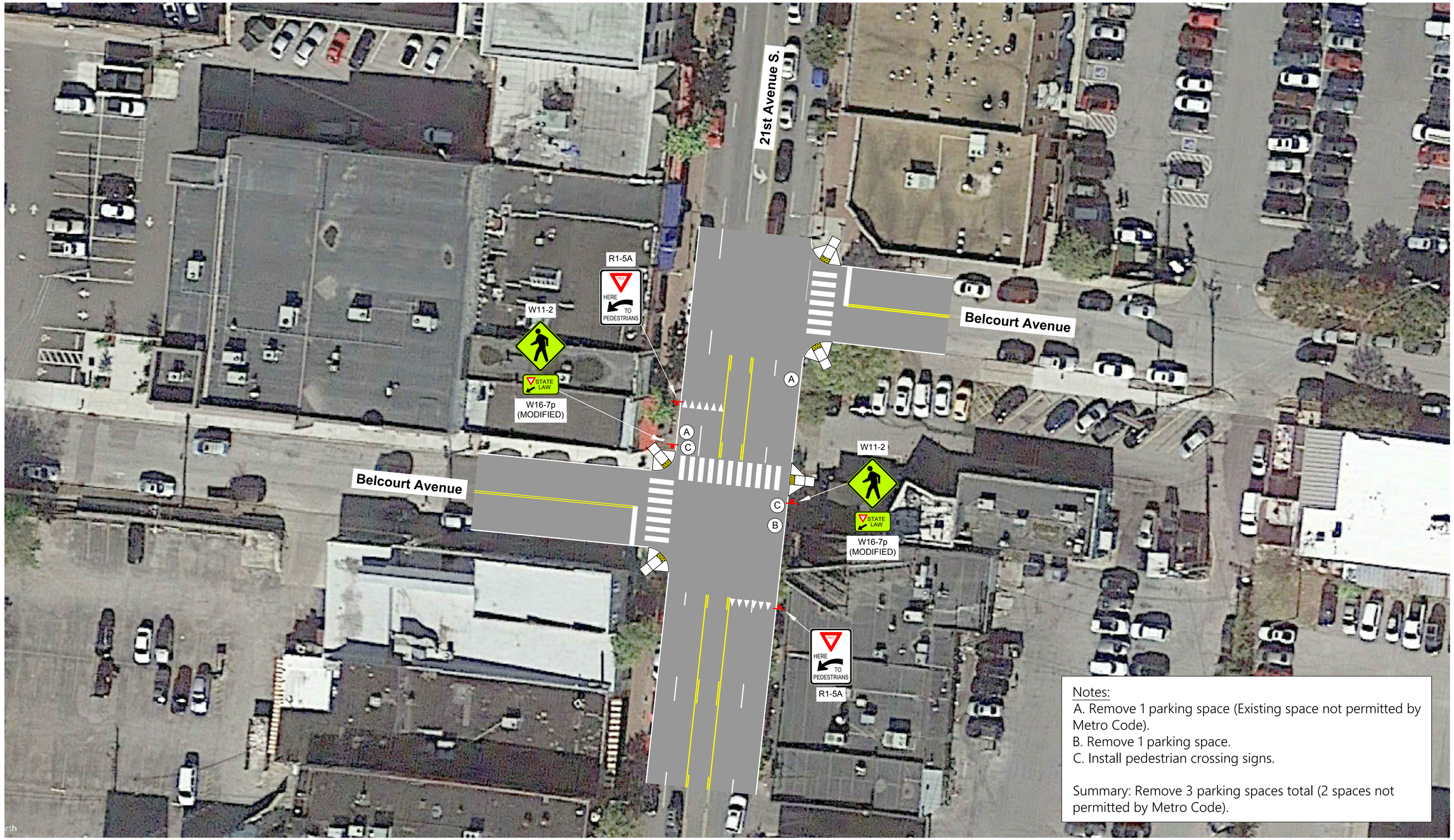
Option 1

GRAPHIC SCALE
0 10' 20' 40' 60'

Pedestrian Improvements
21st Avenue South at Belcourt Avenue in Hillsboro Village



Notes:
A. Remove 1 parking space (Existing space not permitted by Metro Code).
B. Remove 1 parking space.
C. Install pedestrian crossing signs.

Summary: Remove 3 parking spaces total (2 spaces not permitted by Metro Code).

Option 2

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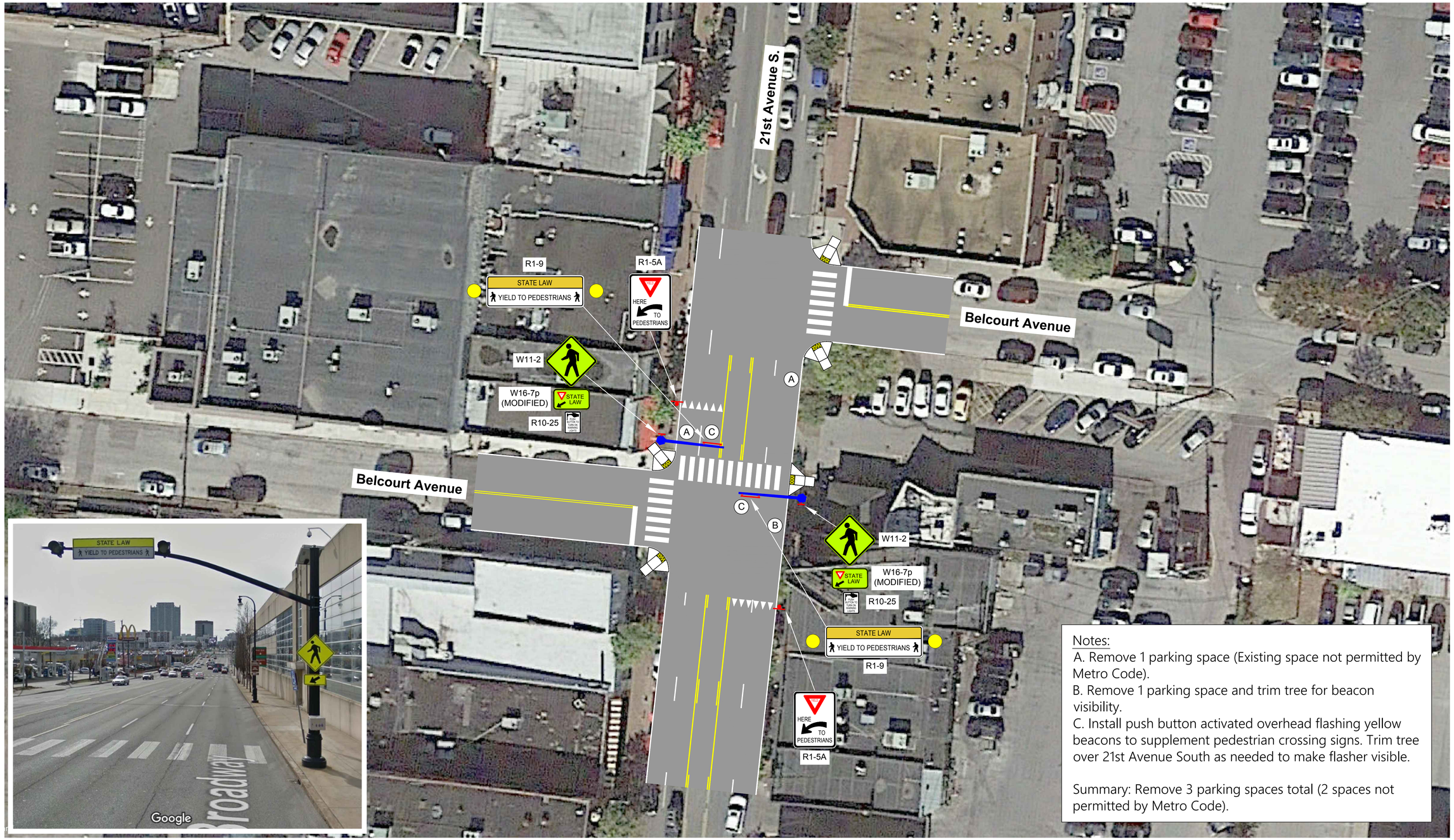
GRAPHIC SCALE
0 10' 20' 40' 60'

Pedestrian Improvements
21st Avenue South at Belcourt Avenue in Hillsboro Village



Notes:
A. Remove 1 parking space (Existing space not permitted by Metro Code).
B. Remove 1 parking space and trim tree for beacon visibility.
C. Install push button activated overhead flashing yellow beacons to supplement pedestrian crossing signs. Trim tree over 21st Avenue South as needed to make flasher visible.

Summary: Remove 3 parking spaces total (2 spaces not permitted by Metro Code).

Option 3 (Preferred)

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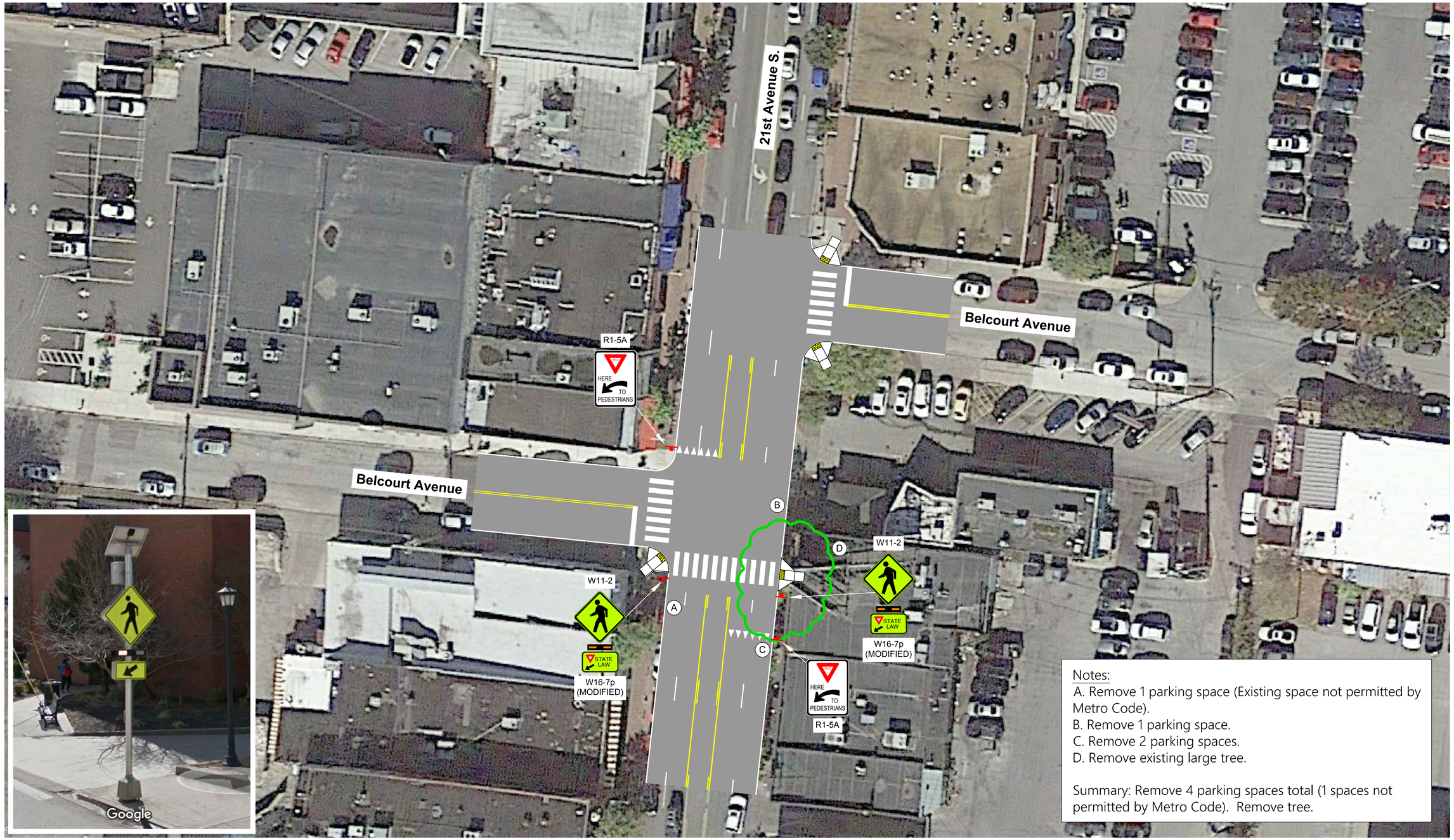
GRAPHIC SCALE
0 10' 20' 40' 60'

Pedestrian Improvements
21st Avenue South at Belcourt Avenue in Hillsboro Village



Notes:
A. Remove 1 parking space (Existing space not permitted by Metro Code).
B. Remove 1 parking space.
C. Remove 2 parking spaces.
D. Remove existing large tree.

Summary: Remove 4 parking spaces total (1 spaces not permitted by Metro Code). Remove tree.

Option 4

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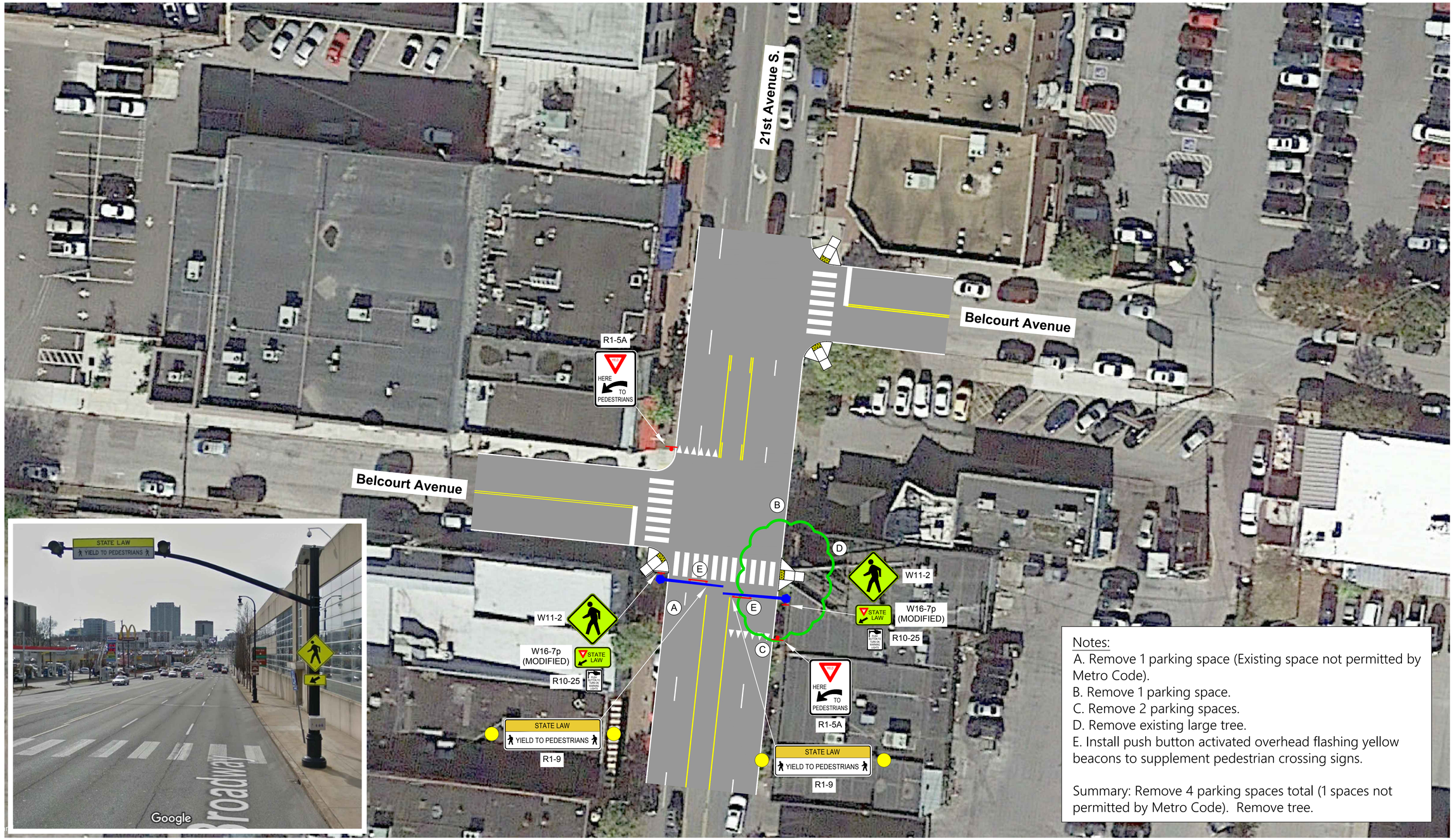
GRAPHIC SCALE
0 10' 20' 40' 60'

Pedestrian Improvements
21st Avenue South at Belcourt Avenue in Hillsboro Village



Notes:

A. Remove 1 parking space (Existing space not permitted by Metro Code).
B. Remove 1 parking space.
C. Remove 2 parking spaces.
D. Remove existing large tree.
E. Install push button activated overhead flashing yellow beacons to supplement pedestrian crossing signs.

Summary: Remove 4 parking spaces total (1 spaces not permitted by Metro Code). Remove tree.

Option 5

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GRAPHIC SCALE
0 10' 20' 40' 60'

APPENDIX B

DESCRIPTION OF TRAFFIC SIGNAL WARRANTS

The *Manual on Uniform Traffic Control Devices* (MUTCD) sets forth nine different warrants that have been developed by the traffic engineering profession to aid in the determination of when a signal is warranted. These warrants present minimum conditions that normally indicate when a traffic signal is justified at a particular location. The MUTCD states that "traffic control signals should not be installed unless one or more of the factors… are met."

Although the MUTCD provides nine different warrants, only five of these are potentially applicable at the location under study. This warrants, described in the MUTCD, are as follows:

Warrant 1, Eight-Hour Vehicular Volume

Warrant 1A, Minimum Vehicular Volume

The Minimum Vehicular Volume warrant is intended for application where the volume of intersecting traffic is the principal reason for consideration of signal installation. The warrant is satisfied when, for each of any eight hours of an average day, the traffic volumes given below in Table B1 exist on the major street and on the higher volume minor street approach to the intersection.

Table B1. Minimum Vehicular Volumes for Warrant 1A

Number of lanes for moving traffic on each approach		Vehicles per hour on major street	Vehicles per hour on higher volume minor approach
Major Street	Minor Street	Total of Both Approaches	One Direction Only
1 Lane	1 Lane	500	150
2 Lanes or more	1 Lane	600	150
2 Lanes or more	2 Lanes or more	600	200
1 Lane	2 Lanes or more	500	200

Warrant 1B, Interruption of Continuous Traffic

The Interruption of Continuous Traffic warrant applies to operating conditions where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or hazard when entering or crossing the major street. The warrant is satisfied when, for each of any eight hours of an average day, the traffic volumes given below in Table B2 exist on the major street and on the higher volume minor street approach to an intersection. Also, the signal installation shall not seriously disrupt progressive traffic flow.

Table B2. Minimum Vehicular Volumes for Warrant 1B

Number of lanes for moving traffic on each approach		Vehicles per hour on major street	Vehicles per hour on higher volume minor approach
Major Street	Minor Street	Total of Both Approaches	One Direction Only
1 Lane	1 Lane	750	75
2 Lanes or more	1 Lane	900	75
2 Lanes or more	2 Lanes or more	900	100
1 Lane	2 Lanes or more	750	100

In exceptional cases, signals occasionally may be justified where no single warrant is satisfied but where Warrants 1A and 1B are satisfied to the extent of 80 percent or more of the stated values. This warrant is referred to as Warrant 1C (Combination Warrant).

Warrant 2, Four-Hour Vehicular Volume

The Four Hour Volume warrant is satisfied when for each of any four high hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher volume minor street approach (one direction only) all fall above the curve in Figure B1, for the existing combination of approach lanes.

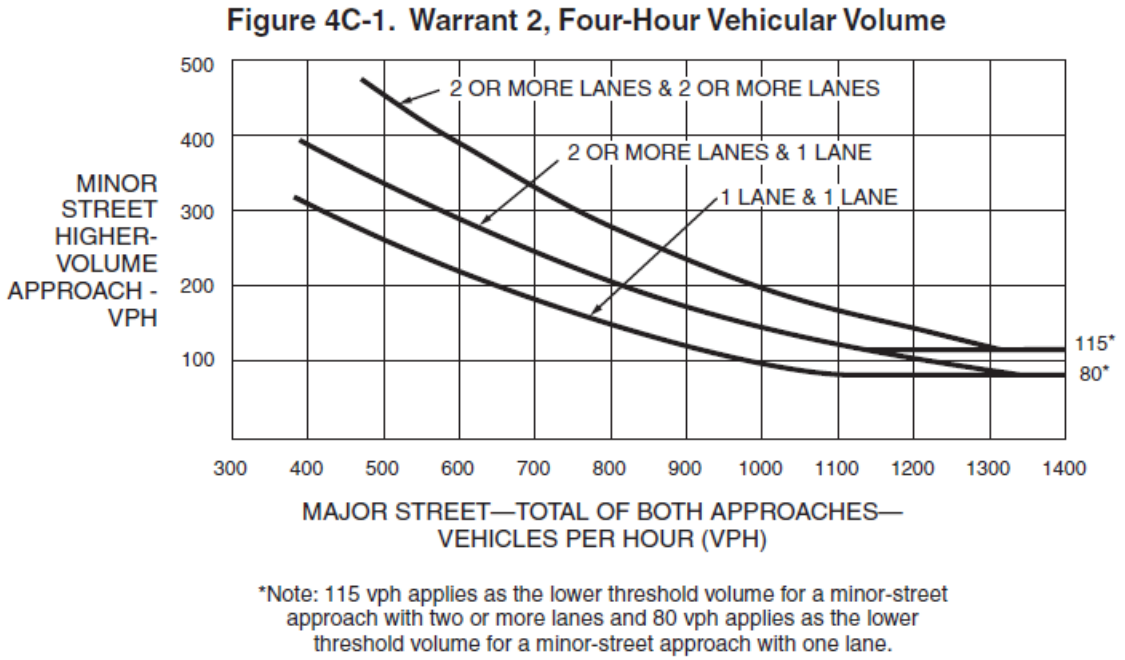

Figure B1. Warrant 2, Four-Hour Vehicular Volume

Warrant 3, Peak Hour

The Peak Hour Volume warrant is intended for application when traffic conditions are such that for one hour of the day, minor street traffic suffers undue traffic delay in entering or crossing the major street.

The Peak Hour Volume warrant is satisfied when the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher volume minor street approach (one direction only) for one hour (any four consecutive 15 minute periods) of an average day falls above the curve in Figure B2, for the existing combination of approach lanes.

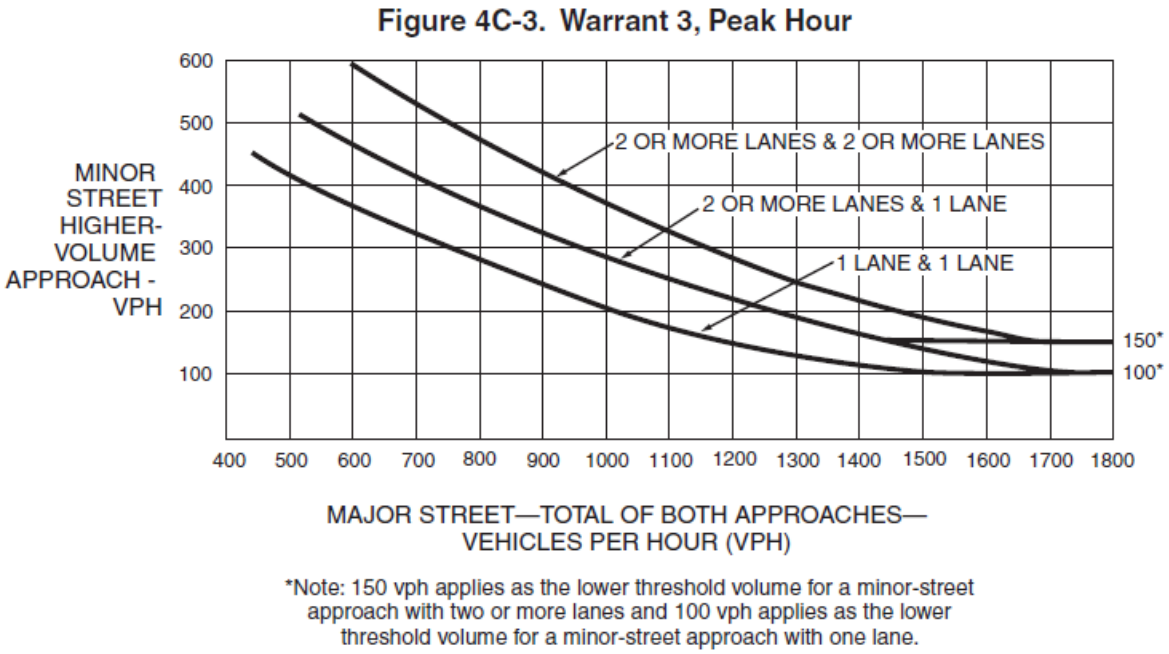

Figure B2. Warrant 3, Peak-Hour Vehicular Volume

Warrant 4, Pedestrian Volume

The Pedestrian Volume warrant is satisfied when for each of any four hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) all fall above the curve in Figure B3; or for one hour (any four consecutive 15-minute periods) above the curve in Figure B4.

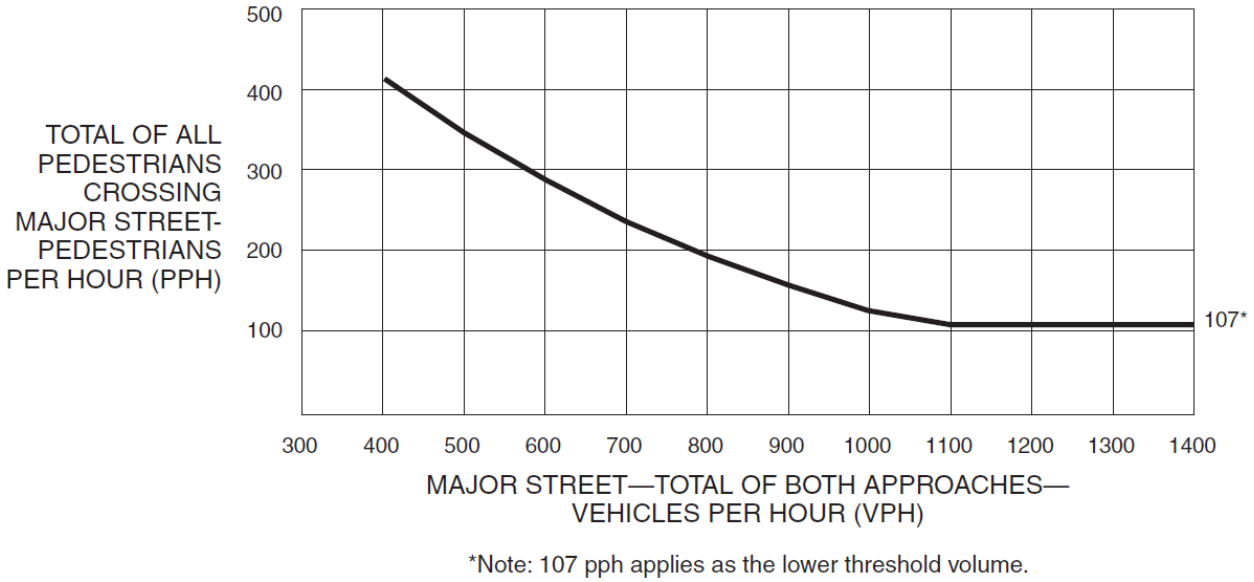

Figure B3. Warrant 4, Pedestrian Four-Hour Volume

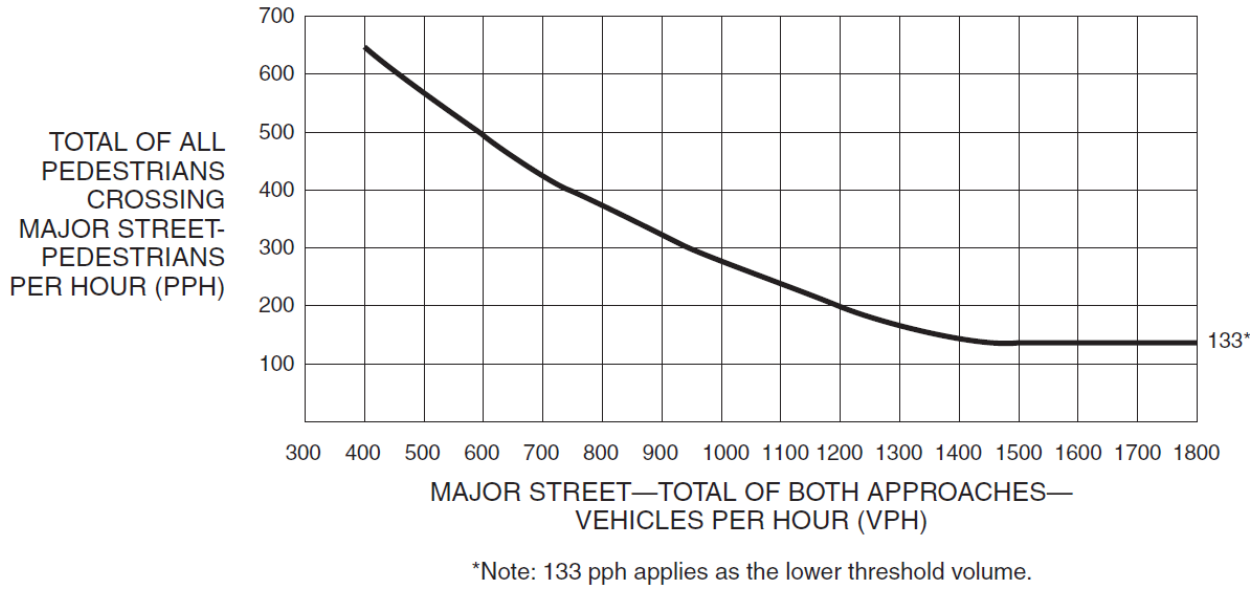

Figure B4. Warrant 4, Pedestrian Peak Hour

Warrant 7, Crash Experience

The Crash Experience signal warrant conditions are intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal. The need for a traffic control signal shall be considered if an engineering study finds that all of the following criteria are met:

A. Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency; and

B. Five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash; and
C. For each of any 8 hours of an average day, the vehicles per hour (vph) given in both of the 80 percent columns of Condition A in Table 4C-1 (Figure B5), or the vph in both of the 80 percent columns of Condition B in Table 4C-1 (Figure B5) exists on the major-street and the higher-volume minor-street approach, respectively, to the intersection, or the volume of pedestrian traffic is not less than 80 percent of the requirements specified in the Pedestrian Volume warrant. These major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

[a] Basic minimum hourly volume
[b] Used for combination of Conditions A and B after adequate trial of other remedial measures
[c] May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000
[d] May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

Figure B5. MUTCD Table 4C-1